Reimagining *Magnolia* x*soulangeana*

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EXECUTIVE SUMMARY

Magnolia x*soulangeana*, most commonly known as the Saucer Magnolia, is a small flowering tree belonging to the Magnoliaceae family. It is an interspecific hybrid of *M. denudate* and *M. liliiflora,* both of which are native to China. It is considered cold hardy through USDA Hardiness Zones 5a, but can be found down through Zone 4b. The tree has a rope-like root system that stays within the first 0.3 meters of soil, and the tree prefers to grow in well-drained, moist soils. The next phase for *M.* x*soulangeana* is to expand its market into woody decorative cuttings through sustainable greenhouse container production. Propagation would still be primarily through the use of stem cuttings, but instead of transplanting the rooted cuttings into the field the following year, they would be planted into their final containers and maintained in a greenhouse. During the winter, the greenhouse would not need to have additional lighting, and

the temperatures in the greenhouse would only have to be maintained to the point where the root systems of the magnolias are not killed. Harvesting of the stems would occur in the early spring, and potentially in the summer if re-blooming types were used. In order to make this system function properly and be sustainable, breeders would need to select smaller cultivars that have a tolerance to drought. Smaller trees would make the system more manageable and give the producer the ability to maintain more trees. Root circling and girdling from the container's restriction would also need to be overcome. Ideally, these smaller cultivars would also have smaller root systems, however it may still be necessary to use copper-coated containers, air-pruning containers, or fabric containers. Research would need to be done to determine the effectiveness of each method. Drought tolerance would make the system more sustainable in that less water would be needed to maintain the plants. Other traits that should be bred for or maintained in the cultivar include longer vase life, color variety, and growth rate, the ability to re-bloom, and higher quality second blooms.

I. INTRODUCTION

A. Study Species.

Magnolias are renowned for their ability to flower in early spring and bring a little color back to the bleak landscape. Of the all of the magnolia species, *Magnolia* x*soulangeana* is considered to be one of the most widely known and the most commonly planted magnolia (Gardiner 2000). Generally, these magnolias are sold in containers by wholesalers and retailers to be transplanted into the landscape by consumers. When planted correctly, flowering in early to mid-spring, these small trees or shrubs explode with gorgeous cup- or saucer- shaped flowers (Gardiner 2000; Raver 1993).

Woody decorative cut florals are materials that come from woody vines, perennial shrubs, or trees and can be used in floral design (Bachmann 2002). Generally, plants used for woody florals will have some sort of unique characteristic such as colored bark, distinct berries or buds, or have exceptional flowers, that can be used in floral design (Trozzo et al. 2012; Meyer et al. 2007). The

aim of this review on Magnolias is to outline the ability of *M.* x*soulangeana* to be grown as a container crop with the flowering stems harvested for use as a woody decorative cuttings in floral design in the Midwest U.S. Currently, most woody floral materials are produced in California, Washington, and Oregon, but there is evidence that indicates that there is a market for woody florals in the Midwest region (Stahl 2004).

B. Taxonomic Classification and Geographic Distribution in the Wild.

Magnolia x*soulangeana* is a member of the Magnoliaceae family and *Magnolia* genus that contains over 250 different species, ranging in ploidy levels from diploid to hexaploid ("Magnolia xsoulangeana" 2015; Gardiner 2000, Parris et. al. 2010). The species name, *soulangeana,* is most commonly spelled with an *e,* but in some it has been known to be spelled with an *i* as *soulangiana*. This hybrid commonly goes by the names of Saucer Magnolia or Chinese Magnolia ("Magnolia xsoulangeana" 2015; Gardiner 2000). It is generally classified as a small, spreading deciduous tree or large shrub that is multi-stemmed (Gilman & Watson 2014; Gardiner 2000). The species can grow to 6 meters to 7.6 meters in height and range from six meters to nine meters in width, although some cultivars can be smaller (Gilman & Watson 2014). *Magnolia* x*soulangeana* has simple obovate to oblong leaves arranged in an alternate fashion, that are usually 20 cm long by 11.5 cm wide (Gilman & Watson 2014; Gardiner 2000). The flowers of *M.* x*soulangeana* are large and terminal (Rhodus n.d.). Depending on the cultivar grown and the location it is grown in, flowers of *M.* x*soulangeana* can be seen displaying various shades of white, pink, red, and purple, often in combination with each other, in early to mid-spring, generally starting sometime in April (Gardiner 2000; Raver 1993). Some cultivars however, can begin flowering as early as February in areas such as California, provided that the weather is favorable (Gardiner 2000). In general, *M.* x*soulangeana* requires a short period of cold before they will flower, but they break dormancy easily (Bogash, 2015). There are some re-flowering cultivars that sporadically flower in the summer and fall ("Getting Started with Magnolias" n.d.). Usually, if a magnolia contains *M. liliiflora* in their background, like *M.*

x*soulangeana* does, they have the potential to re-flower later in the season under the right conditions (Galitzki 2001). The fruit that subsequently develops is 2.5 cm to 7.5 cm in length, irregular in shape, and red in color (Gilman & Watson 2014). The root system of *M.* x*soulangeana* generally develops within the top 0.3 meters of soil and does not go much deeper (USDA 2006). The roots of the tree are rope-like and are mostly unbranched (USDA 2006). Many cultivars of this hybrid exist today. Table 1 (shown below) lists just a few of many cultivars of *M.* x*soulangeana* mentioned in Gardiner's book *Magnolias: A Gardener's Guide* (2000). Most of the cultivars listed in the table have some coloring of pink, red, or purple, and very few of them are pure white. It should also be noted that *M.* x*soulangeana* 'Alexandria' is one of the most sought after cultivars of this hybrid (Honey Tree Nursery 2015). More cultivars and series will be discussed later in this paper.

Being adept to a variety of environments and soil ranges, *M.* x*soulangeana* is a relatively easy plant to grow (Gardiner 2000; Treseder 1978). They can endure more wind than some other flowering tree types, as well as city pollution, heat, cold, dust, and negligence (Treseder 1978). Ideally, *M.* x*soulangeana* prefers to be grown in a well-drained, slightly acidic soil, ranging in a soil type of clay, sand, or loam ("Magnolia xsoulangeana" 2015; Gilman & Watson 2014). They also prefer to be grown either in full sun or part sun/part shade (Gilman & Watson 2014). The USDA Hardiness Zones for *M.* x*soulangeana* are USDA Zones 5a through 9a, but they can also be seen in Zones 4a and 4b (Gilman & Watson 2014). *Magnolia* x*soulangeana* is prone to winter damage, however, in the colder zones, and early flowering cultivars are susceptible to late frosts (Covey 2004). Despite being so tolerant of various environmental conditions, *M.* x*soulangeana* is considered to have a relatively low invasive potential and is therefore classified as non-invasive (Gilman & Watson 2014).

Magnolia x*soulangeana* is an interspecific hybrid of *M. denudata* and *M. liliiflora*, both of which are native to China (Gardiner 2000). *Magnolia denudata* is specifically native to the central Chinese Provinces of Anhui, Zhejiang, Hunan, and Jiangxi, while *M. liliiflora* is native to

the Eastern and Central Providences of Fujian, Hubei, and Zhejiang (Gardiner 2000). To the best of my knowledge, no published information exists that documents *M.* x*soulangeana* occurring naturally in the wild. Since *M. denudata* blooms from February to April and *M. liliiflora* flowers from mid-April into June and each species share a small portion of native range, it is unlikely that *M.* x*soulangeana* exists naturally in the wild (Gardiner 2000). However, undiscovered hybrids may have existed before 1830, since both of these species were cultivated and planted in temple gardens throughout China, Japan, and Korea within a close vicinity to each other (Gardiner 2000). Both species are normally found growing in the wild with other deciduous, broad-leaved trees as well as some coniferous trees in soils with high humus and moisture contents (Gardiner 2000). Magnolias can also be found growing along the low slopes of mountains and on the margins of ponds and streams (Gardiner 2000).

Cultivars	Description
'Alba Superba'	Early bloomer, white tepals, basal of flower pink to purple, saucer or cup shaped flower
'Alexandria'	Tulip shaped flower 10 cm to 11.5 cm long, outside of flower is either completely white or has a purplish tint, inside flower is completely white, very fragrant, hardy cultivar, flowers early April
'Brozzoni'	Saucer or cup shaped flower 14 cm long, flowers late April, white flowers with pinkish tint inside of the flowers
'Burgundy'	Pink, red, or purplish flowers 20 cm wide
'Coates'	Saucer or cup shaped flower, outside of flower is pinkish red, and the inside flower is white or pink
'Dark Splendor'	Reddish wine colored flowers, upright habit
'Grace McDade'	White flowers with a pink or purple tint, flowers 30 to 35 cm wide
'Just Jean'	Flowers mid-April, produces globe shaped flowers that are pink in color and dark pink at the base, compact habit with large obovate leaves
'Lennei'	Free-flowering and grows fast, tulip-shaped flowers that are purplish red on outside and white on the inside, flowers late
'Lennei Alba'	Inverted flask shaped flower that are white in color
'Lilliputiana'	Smallest of the cultivars listed, white flowers with pinkish tints
'Norbertii'	Flowers early April, white flowers with pinkish tint that are 10 cm long, globe shaped flowers, faintly fragrant
'Picture'	Cup or saucer shaped flower 15 cm to 17.5 cm long, purplish red color outside of flower and white to pinkish white inside
'Pickard's Garnet'	Globe shaped flowers, red-wine colored
'Pickard's Opal'	Globe shaped flowers, white in color with purple tinging at the base of the flower
'Pickard's Ruby'	Globe shaped flower, purple-red colored flowers
'Pickard's Schmetterling'	White colored flowers with reddish-purple outside, flowers 15 cm long
'Pickard's Snow Queen'	Vase shaped flower, white in color
'Pickard's Sundew'	Globe shaped flower, pink colored outside, white colored inside with an orange undertone
'Rustica Rubra'	Cup or goblet shaped flower, flowers mid-April, purplish red flowers on the outside while pinkish white on the inside
'San Jose'	Cup or goblet shaped flower, flowers dark pink on outside and white on inside, flowers late
'Triumphans'	Cup or goblet shaped flower, reddish color on the outside of the flower and pink white on the inside of the flower, flowers in mid-April
'Verbanica'	Cup shaped flower, flowers pink in color that fades to the tips of the tepals, flowers mid-April to May
'White Giant'	Cup or goblet shaped flower that are large in size, flowers white

Table 1: List of commonly grown *Magnolia* x*soulangeana* cultivars (adapted from Gardiner 2000)

II. CROP HISTORY

A. Breeding & Domestication.

Magnolia x*soulangeana* is named after Etienne Soulange-Bodin, who is credited with the first intentional breeding of the hybrid (Gardiner 2000; Raver 1993). Before becoming the creator of one of the best known most widely grown magnolias, Soulange-Bodin was a French cavalry officer in Napoleon's army (Gardiner 2000; Raver 1993; Treseder 1978). Following the end of the Napoleon war, he returned home to become the founder and first director of the Royal Institute of Horticulture at Fromont, near Paris, France (Gardiner 2000; Treseder 1978). It is said that in 1820, Soulange-Bodin took a *M. denudata* and pollinated it with pollen from a *M. liliiflora* (Gardiner 2000; Treseder 1978). It wasn't until 1827 that the hybrid flowered and its true beauty was revealed (Gardiner 2000; Treseder 1978). Since its initial creation, there have been over 100 cultivars of *M.* x*soulangeana* published (Gardiner 2000).

During the 1920s, nursery firms such as Young's Nursery and Vauxhall Nursery and the Royal Horticultural Society were in charge of introducing new plants to the public (Gardiner 2000). To the best of my knowledge, no published information exists that divulges the challenges involved in the early developmental stages of *M.* x*soulangeana.* However, breeding new hybrids or cultivars using *M.* x*soulangeana* may be difficult. *Magnolia* x*soulangeana* is a pentaploid hybrid; its parents, *M. denudate* and *M. liliiflora*, were a hexaploid and a tetraploid respectively (Parris et. al. 2010). Because it has an odd number of chromosome sets, the fertility of certain M. xsoulangeana varieties may be questionable. Research conducted by Parris et. al. (2010), however, has found that F1 hybrids of M. xsoulangeana and its subsequent generations are able to produce aneuploid offspring with ploidy levels ranging from about 4.6 to 8.5 depending on the genome size.

Figure 1, adapted from Drew et al. (2012), displays the plant distribution chain for *Magnolia* x*soulangeana.* At the top of the chain are the plant explorers or those who initially discovered the plant. It is likely that Buddhist monks were the first plant explorers who initially found both

parents of *M.* x*soulangeana*, since both *M. denudata* and *M. liliiflora* have been propagated for centuries by them and were found temple gardens (Gardiner 2000). Following plant explorers is the collected germplasm, which would be the *M. denudata* and *M. liliiflora* used in the initial crossing of *M.* x*soulangeana* by Soulange-Bodin. This section could also include the germplasm used in the development of subsequent cultivars of *M.* x*soulangeana.* The public/private sector breeding programs and breeder companies would encompass Soulange-Bodin as well as Cels of Montrouge who introduced the cultivar 'Alexandria,' Leonard Coates Nursery who introduced the 'Coates' cultivar, and John Gallagher who introduced the 'Just Jean' cultivar to name a few (Gardiner 2000). From the public/private sector breeding programs and breeding companies comes the seed products and vegetative products. These products are then generally given to wholesalers to propagate and distribute to other wholesalers, retailers, or consumers. Some examples of wholesale nurseries in the United States that sell magnolias are Moon Nurseries, King Nursery, Cedar Valley Nurseries, and Schumacher F.W. Co. Inc. ("Plant and Seed Sources" n.d.). Schumacher F.W. Co. Inc. in particular sells *M.* x*soulangeana* seeds ("Plant and Seed Sources" n.d.). Some examples of retailers that sell *M.* x*soulangeana* are as follows: Farmer Seed & Nursery, McKay Nursery Co., Davidson Greenhouse & Nursery Inc., and Whitney Gardens & Nursery ("Plant and Seed Sources" n.d.). Today, the majority of magnolia suppliers raises the plants from vegetative cuttings or use budding or grafting techniques (Gardiner 2000). Very few firms raise magnolias from seed because there is often doubt about the seedlings male parent (Gardiner 2000).

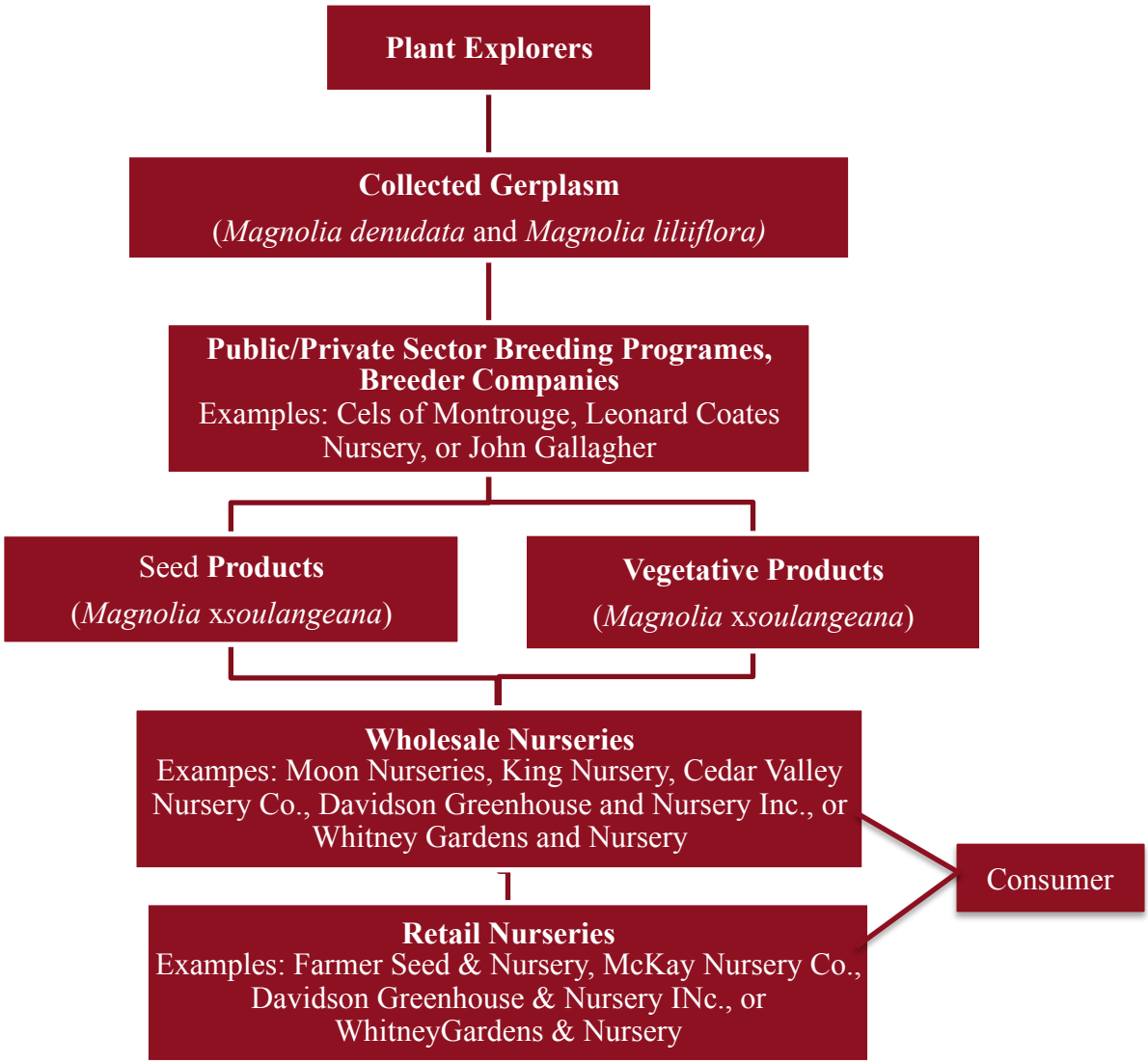

Figure 1: *Magnolia* x*soulangeana* plant distribution chain (Adapted from Drew et al. 2010).

III. PRODUCTION INFORMATION

A. Current Production Practices.

The current production practices of magnolia involve propagation by seed or by vegetative cuttings, grafting, budding, layering or micropropagation (Hartmann 2011; Gardiner 2000; Treseder 1978). Below, two of these production practices are discussed: seed propagation and stem cuttings. These production schedules are also visually laid out in Figures 2 and 3.

Seed propagation, though not as common due to seedling variation, doubt of a seedling's male parent and the time it takes until the plant is mature enough to bloom, is still occasionally used today (Gardiner 2000; Treseder 1978). Before planting, seeds are cleaned and stratified for approximately 100 days at temperatures between 1.7 and 4.4 °C (Hartmann 2011; Treseder 1978). At the end of this period, generally sometime in March, the seeds are planted 1.25 cm deep into seed trays 2.5 cm apart or into small pots (Treseder 1978). The trays or pots are placed in a propagating frame with bottom heat and shading (Treseder 1978). Once the seeds have germinated, the seedlings are progressively exposed to more intense daylight each day to prevent them from developing stretched internodes (Treseder 1978). When the seedlings reach a height between 2.5 cm and 5 cm, they are transplanted into 6 cm diameter pots containing a light compost. These are kept in a shaded greenhouse with high humidity for approximately one to two weeks, during which time the seedlings recover from the shock of transplanting (Treseder 1978). As soon as the seedlings reach a height of 15 cm, they are either transferred to a cold frame to be hardened off or transplanted again into pots 10 cm to 11.5 cm diameter pots containing a firmer compost (Treseder 1978). If they are transplanted, they remain in the greenhouse until October during which time they can reach a height of 30.5 cm. At the end of October they are moved to a cold frame (Treseder 1978). The following spring, the magnolias are transplanted into a field with partial shade; in the field they are individually planted 23 cm apart with rows spaced 30.5 cm apart (Treseder 1978). They are maintained in the field for an additional 1 to 5 years; it is recommended to leave them in the field for 4 to 5 years before moving them to their final destination, during which they are able to reach a height of 1.2 to 1.5 meters (Treseder 1978). Depending on the cultivar grown, it can take 10 to 20 years before a seedling reaches maturity and blooms (Treseder 1978). Figure 2 displays the production schedule using *M.* x*soulangeana* seeds, that was discussed above.

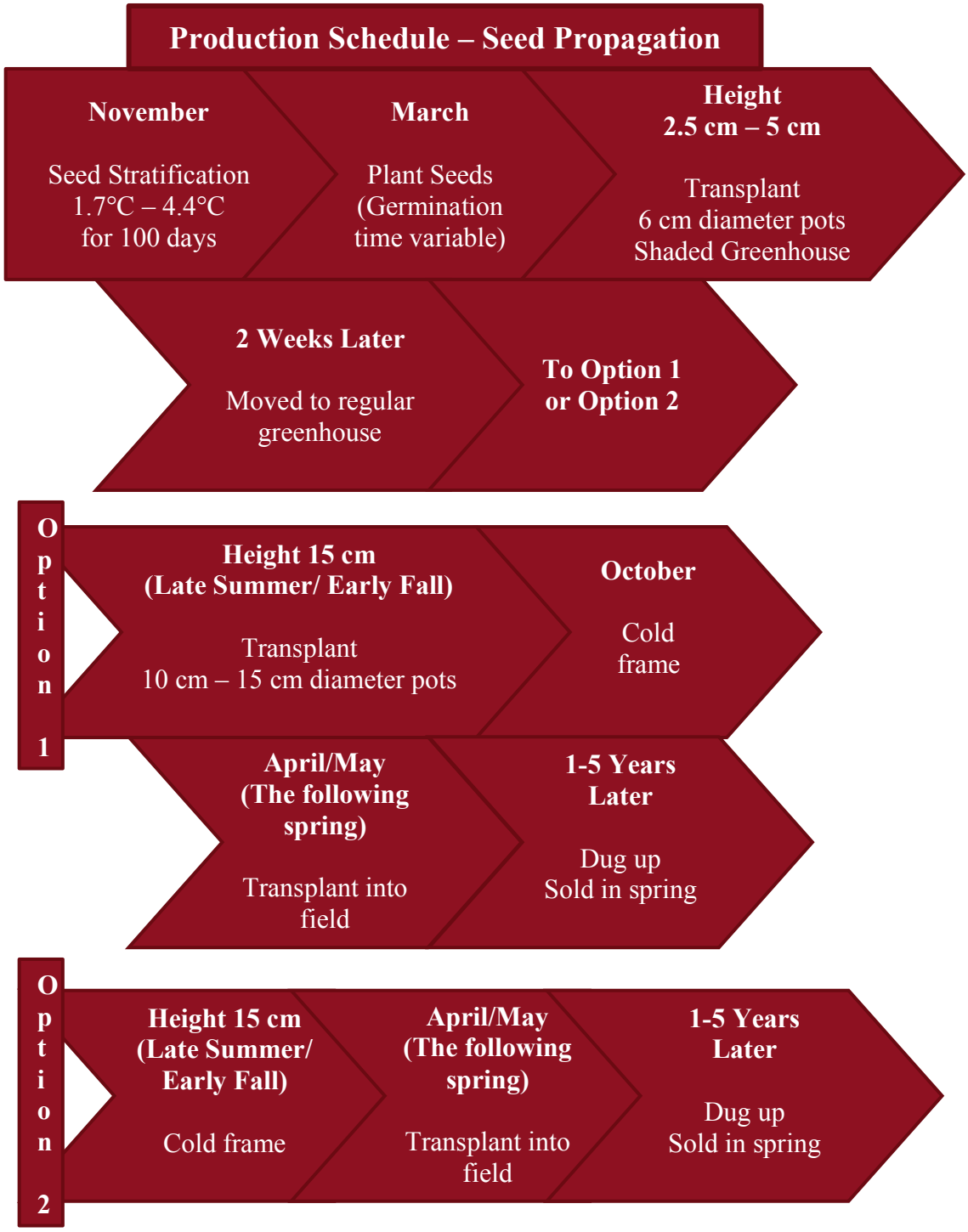

Figure 2: Seed propagation production schedule for *M.* x*soulangeana* (adapted from Hartmann 2011 and Treseder 1978).

When propagating with stem cuttings, soft or half-ripe cuttings are used instead of hardwood cuttings (Treseder 1978). This is because magnolias do not commonly root from hardwood cuttings (Treseder 1978). Cuttings with three to six leaves are taken from lateral or side branches between late spring to late summer from stock plants, when the terminal growth has completely stopped (Hartmann 2011; Treseder 1978). The heel of old wood is not included in these cuttings and flower buds are removed (Hartmann 2011; Treseder 1978). Depending on the propagator, synthetic rooting hormones are used prior to placing them into rooting media; *Magnolia* x*soulangeana* is generally treated with 8000 ppm IBA (Hartmann 2011; Treseder 1978). A fungicide, such as Captan, is then applied following the cuttings placement into the soil media and is reapplied every two weeks (Treseder 1978). The media used in the propagation of magnolia cuttings are either sand, a peat moss-sand mixture, vermiculite, or perlite; vermiculite and perlite are sometimes favored due to their light weights (Treseder 1978). The cuttings are maintained in a greenhouse using bottom heat that keeps the rooting medium between 21 to 24 degrees Celsius (Treseder 1978). Intermittent mist is also used to increase humidity and reduce the loss of water from the cuttings (Treseder 1978). Two to five weeks later, cuttings generally have become well rooted and are transplanted into 6 to 7.5 cm diameter pots (Hartmann 2011; Treseder 1978). These are kept under high humidity in the greenhouse for another one to two weeks (Treseder 1978). At the end of this period, the cuttings are transferred to cold frames to harden off (Treseder 1978). The following spring, they are transplanted into well-prepared, part-shade beds and spaced 23 cm apart in rows spaced 30.5 cm away from each other; here they are maintained for an additional one or two years before they are sold (Treseder 1978). All magnolias rooted from cuttings have poor winter survival, so it is important to root cuttings as soon as possible and allow them to build up their storage capacity before going dormant (Hartmann 2011). Figure 3 (below) displays the production schedule using stem cuttings for *M.* x*soulangeana* that was discussed above.

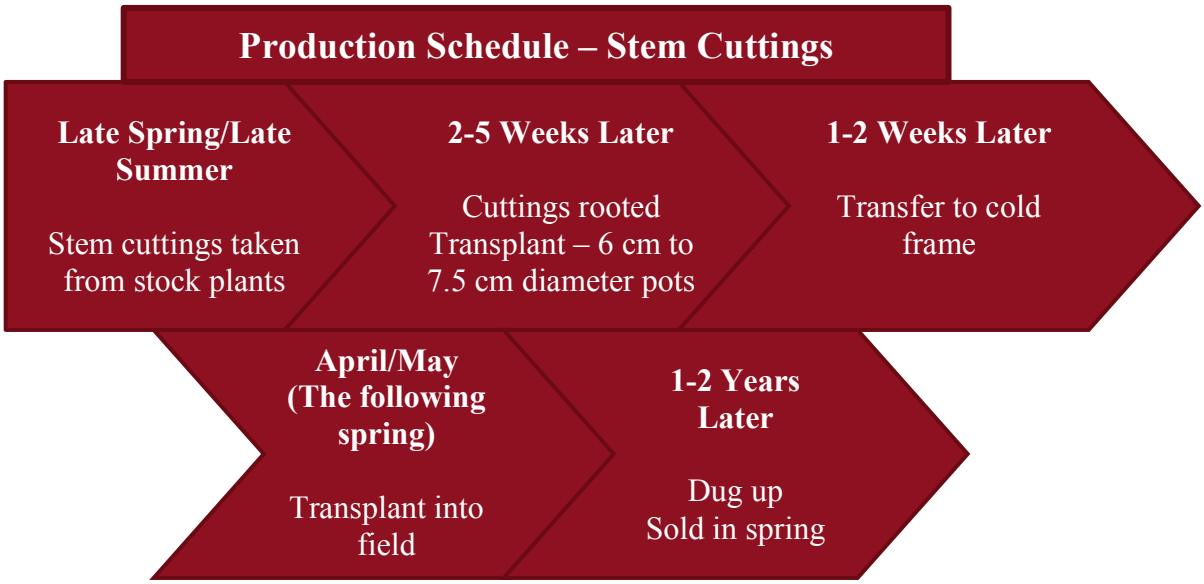

Figure 3: Stem cutting production schedule for *M.* x*soulangeana* (adapted from Hartmann 2011 and Treseder 1978).

Sustainability is an important consideration for the production of magnolias in the future. Filtering from the information above, one can deduce that the essential structures and equipment used in the propagation of magnolias are greenhouses, cold frames, mist systems, and bottom heat; all of these listed require some input of electricity to function correctly. Cold frames are the only exception to this statement, if nighttime heating is not used, since cold frames are structures that use the sun in order to heat the internal environment (Nelson 2003). Nighttime heating can be done sustainably, however, through the collection of passive solar heat during the daytime (Nelson 2003). This means that cold frames require relatively little energy input and are considered high on the suitability scale. Greenhouses, in contrast, are enclosed structures that use the sun and various equipment in order to control different factors that affect plant growth (Nelson 2003). Because of the control these structures provide, they require a much larger energy input when compared to cold frames (Nelson 2003). The sustainability of greenhouses can be improved, however, through various means such as greenhouse curtains, caulk sealing, bubble

wrap, sustainable fuel and energy sources, and the use of light emitting diode (LED) lighting. Greenhouse curtains are portable panels made of polyethylene, polyester film, aluminized polyester film strips, or polyester film cloth used to retain heat in the greenhouse; their usage could reduce the fuel consumption of the greenhouse by 20-60% (Nelson 2003). The reduction of heat lost could also be reduced by sealing air leaks with caulk and using bubble wrap on the northern walls of the greenhouse (Nelson 2003). Ventilation systems for the summer months will also need to be implemented; air temperature sensors that automatically adjust the venting systems are often preferred by growers (Deden et. al. 2013). Using sustainable fuel and energy such as solar, wind, and geothermal energy also would increase the sustainability of the greenhouse operation (Nelson 2003). Supplemental lighting, unless certain plastics are used as covering, would not be required in the continual maintenance of established *M.* x*soulangeana* plants, since they are grown normally under Minnesota lighting conditions and are commonly grown in northern climates. However, the use of an adjustable LED system might be needed in propagation of stem cuttings when it is necessary to slowly introduce them to more intense light. The use of an LED system can conserve between 50-75% high intensity discharge energy and lasts longer than conventional greenhouse lighting systems (Nelson 2003). Furthermore, during the winter, *M.* x*soulangeana* is dormant, so the greenhouse would only need to be maintained at a temperature that would not kill the roots. The root killing temperature for *M.* x*soulangeana* grown in containers is -5 °C (Dunwell & McNiel 2005). A "pot-in-pot" method, in which containerized plants are placed into the ground with the upper rim of the container remaining just above ground level, could also be utilized; this would allow the greenhouse temperature to be maintained at an even lower temperature than would be if the containers remained above ground (Ruter 1993). Depending on the cultivar, *M.* x*soulangeana* has low to moderate tolerance to drought (Kuhns & Rupp 2000; Gilman & Watson 1994). Because it doesn't perform well in dry media, water sustainability should be implemented to reduce water waste. One method that could be implemented is the use of capillary water mats, which are constructed of two polyethylene

layers; the top layer is perforated and the bottom layer is not (Schuch & Kelly 2006). When a container is placed on the mat, the media in the container is able to take up water. Through the use of these mats, water is not lost through evaporation, and the plants are maintained at a constant moisture level (Schuch & Kelley 2006). In a study conducted by Schuch and Kelly, they found that the use of capillary mats has the ability to save up to 70% of water as compared to overhead irrigation (2006).

B. Current Production Statistics.

In the United States, magnolias, such as *M.* x*soulangeana,* are classified under the deciduous flowering trees section in the census of horticultural specialties (USDA 2009). According to the 2009 census, 3,734 operations in the United States were involved in the deciduous flowering tree market, and 825 of these operations were marketing magnolias (USDA 2009). Of the 825 magnolia operations, 590 operations were classified as wholesale and 330 were classified as retail (USDA 2009). That year, 746,800 of the 20,761,489 deciduous flowering trees sold were magnolias (USDA 2009). Wholesale operators successfully sold 715,545 of these magnolias, and retail producers sold 31,261 of them (USDA 2009). On January 1, 2010, 713 of the 825 operators had 1,842,272 trees still on the operation site (USDA 2009). Deciduous flowering trees brought in a total of $343,651,000; $305,042,000 came from wholesale operations and $38,609,000 came from retail operations (USDA 2009). Five percent of these total sales came from magnolia sales, meaning magnolia transactions made $18,287,000 of the $343,651,000 (USDA 2009). In wholesale and retail, magnolias made $16,985,000 and $1,329,000 of the $18,287,000 respectively (USDA 2009). The wholesale value of magnolias makes up six percent of the total wholesale value, and the retail value of magnolias makes up below, display the total value, wholesale value, and retail value of magnolias discussed above in relation to other popular deciduous flowering trees sold in 2009.

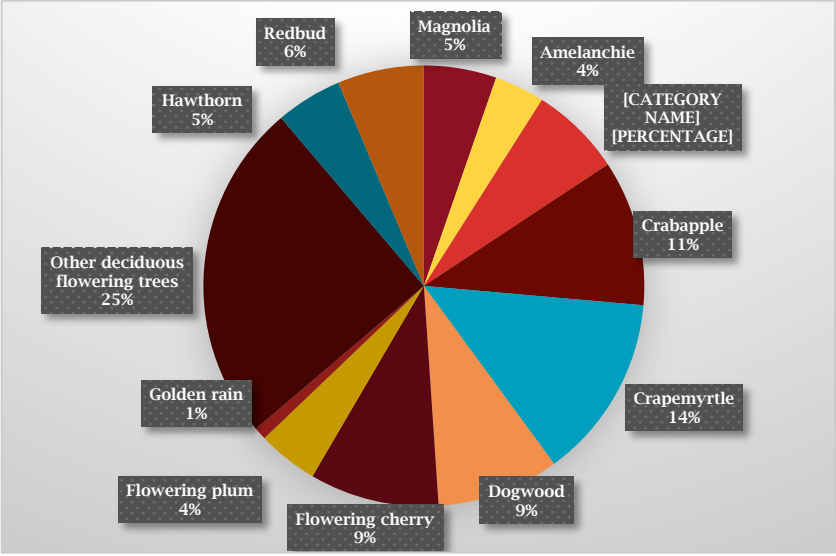

Figure 4: Total production (wholesale and retail) of deciduous flowering trees by value in 2009 (adapted from USDA 2009)

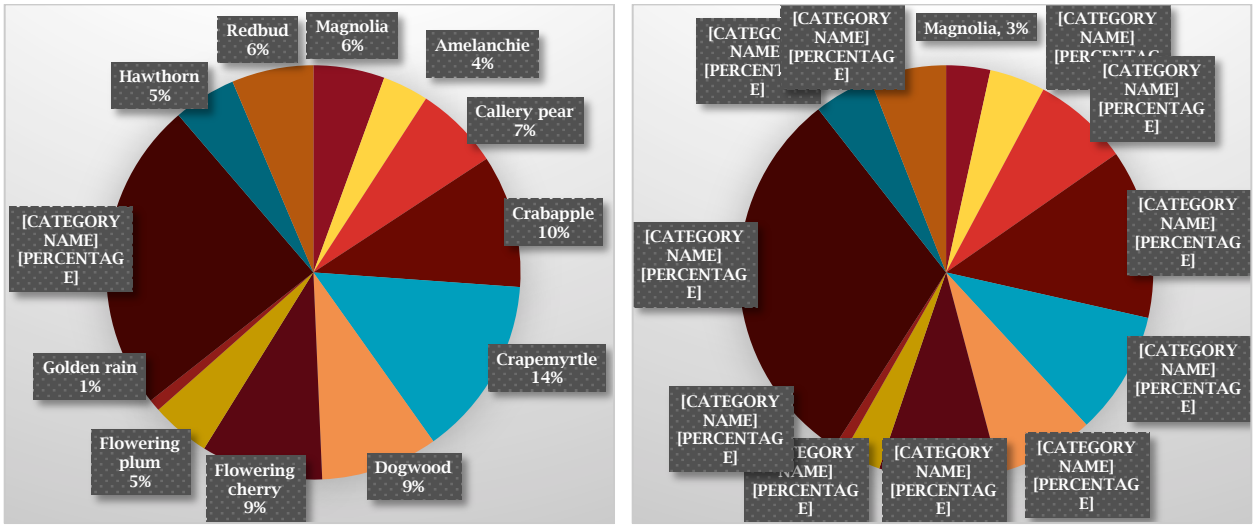

Figure 5a & 5b: Wholesale production (left) and retail production (right) of deciduous flowering trees by value in 2009 (adapted from USDA 2009).

In terms of cut-foliage and branches, the top three countries in export value are the Netherlands, United States, and Costa Rica (Hanks 2015). The Netherlands exported $124.22 million worth of cut branches and foliage, compared to the United States $73.1 million, and Costa Rica's $40.34 million (Hanks 2015). The other 12 countries that are top exporters of cut-foliage and branches include Italy, Israel, Guatemala, Mexico, Germany, South Africa, Denmark, Canada, France, Spain, Sri Lanka, and El Salvador (Hanks 2015). The top three importers of cut foliage and branches are the Netherlands, Germany, and Belgium, with values of $171.15

million, $68.7 million, and $30.67 million respectively (Hanks 2015). The other top countries that constitute the top 15 are the United Kingdom, France, Italy, Denmark, Czech Republic, Austria, Poland, Lithuania, Spain, Finland, Sweden, and Slovakia (Hanks 2015). Figure 6 and Figure 7 (below) are bar graphs depicting the export and import values by country.

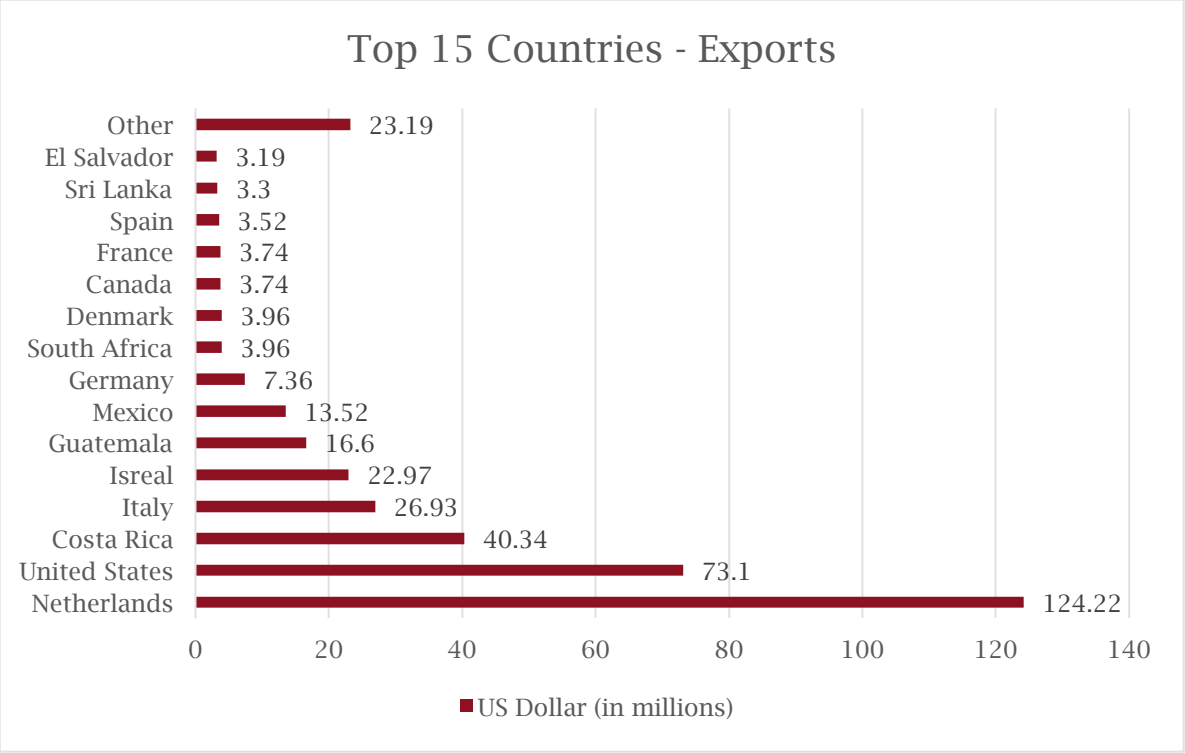

Figure 6: Bar graph comparison for the top 15 countries of cut-foliage and branch exports in terms of US dollar value (adapted from Hanks 2015).

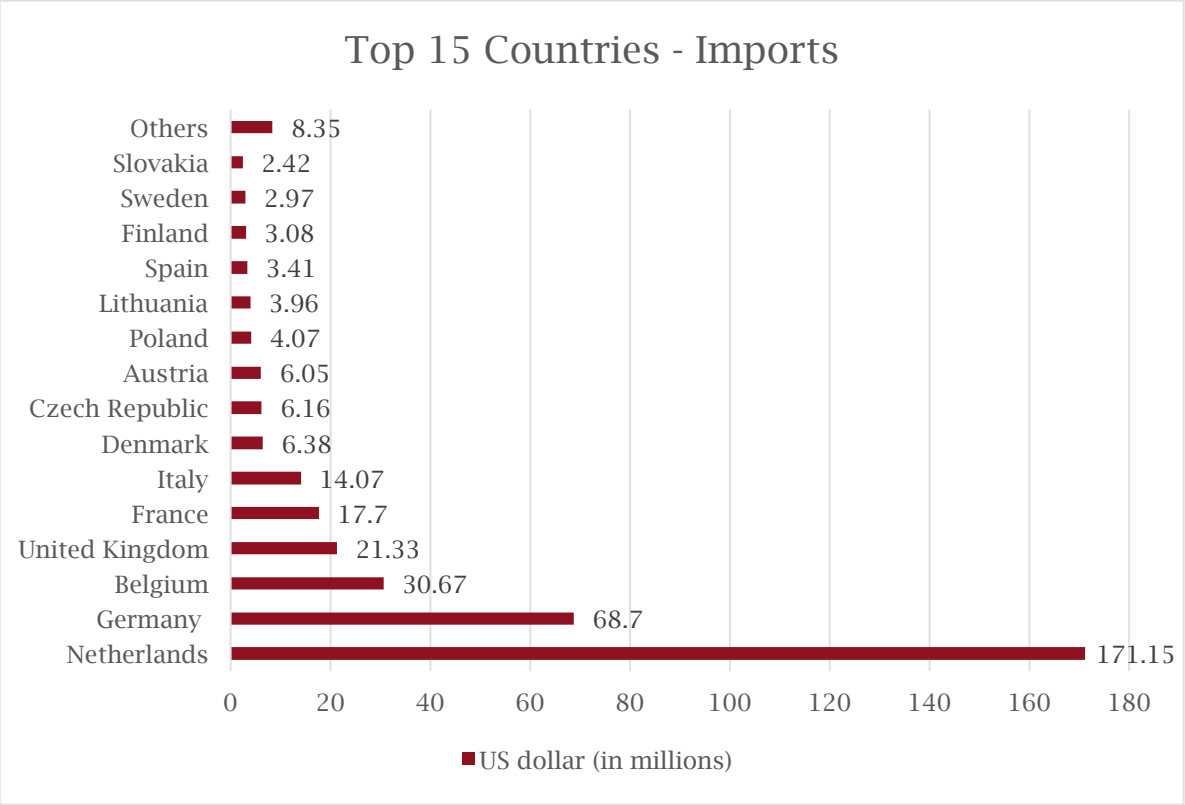

Figure 7: Bar graph comparison for the top 15 countries of cut-foliage and branch imports in terms of US dollar value (adapted from Hanks 2015).

As mentioned in breeding and domestication section, there are over 100 different cultivars of *M.* x*soulangeana* in existence today (Gardiner 2000). Some of these are considered more desirable or more important than others. *Magnolia* x*soulangeana* 'Alexandria,' for example, is one of the most sought after cultivars; it grows five to six meters in height and explodes with pink flowers sometime in April (Honey Tree Nursery 2015). Some other notable cultivars of *M.* x*soulangeana* include 'Black Tulip™,' 'Brozzonii,' 'Coates,' 'Kiki's Broom,' 'Lennei,' 'Lilliputian,' 'Rustica Rubra,' and 'Verbanica' (Plant Information Online n.d.). The descriptions for 'Alexandria,' 'Brozzonii,' 'Coates,' 'Lennei,' 'Lilliputian,' 'Rustica Rubra,' and 'Verbanica' are be seen in Table 1 (above). *Magnolia* x*soulangeana* 'Black Tulip™' is a more recently released cultivar developed by Mark Jury (Jury Magnolias n.d.). This cultivar reaches a height between 3.7 meters and 5.5 meters and has deep red to purple flowers that resemble tulips (Jury

Magnolias n.d.). *Magnolia* x*soulangeana* ‘Kiki’s Broom’ is a slow growing variety that has white to pink flowers and only reaches a height of about 0.61 meters and width of about 1.5 meters (Buchholz & Buchholz Nursery 2015).

An important series of magnolia is the “Eight Little Girls” or just “Little Girls” series that is made up of eight hybrid cultivars (Gardiner 2000). These cultivars were developed by de Vos and Kosar and were selected based on blooming times, hardiness, habit, fragrance, mildew resistance, and their ability to flower prolifically (Gardiner 2000). The cultivars in this series include ‘Ann,’ ‘Betty,’ ‘Judy,’ ‘Randy,’ ‘Ricki,’ ‘Susan,’ ‘Jane,’ and ‘Pinkie’ (Gardiner 2000). The first six of this of this series were created by crossing *M. stellata* ‘Rosea’ with *M. liliiflora* ‘Nigra,’ while the last two in the series were created by crossing *M. liliiflora* ‘Reflorescens’ with *M. stellate* ‘Waterlily’ and crossing *M. liliiflora* ‘Reflorescens’ with *M. stellata* ‘Rosea’ (Gardiner 2000). The first six in this series are sometimes classified as *M.* x*soulangeana* because *M. liliiflora* ‘Nigra’ is sometimes classified as *M.* x*soulangeana* (Gardiner 2000). All eight of these cultivars have the potential to re-bloom in the summer if they are healthy, receive enough water and sunlight, and the temperatures are favorable (Galitzki 2001). However, this second flowering is considered to have “second rate flowers” because the flowers tend to be smaller and marginally distorted compared to the flowers in early spring (Galitzki 2001). Table 2 (below) gives further descriptions of the “Little Girls” series.

Variety	Cross	Description
'Ann'	*M. stellata* 'Rosea' with *M. liliiflora* 'Nigra' (*M.* x*soulangeana* 'Nigra')	Blooms early to mid-April, flowers 10 cm wide, red/purple/pink flowers, upright habit
'Betty'	*M. stellata* 'Rosea' with *M. liliiflora* 'Nigra' (*M.* x*soulangeana* 'Nigra')	Blooms early to mid-April, flowers 20 cm wide, flowers white on the inside red/purple on outside, tree and shrub habit depending on where its grown
'Judy'	*M. stellata* 'Rosea' with *M. liliiflora* 'Nigra' (*M.* x*soulangeana* 'Nigra')	Blooms late April, candle-like flowers 7.5 cm wide, flowers white on the inside and red/purple on the outside, fastigiate habit
'Randy'	*M. stellata* 'Rosea' with *M. liliiflora* 'Nigra' (*M.* x*soulangeana* 'Nigra')	Blooms vigorously mid- to late April, flowers 12.5 cm wide, flowers white/pink on inside and red/purple on outside, columnar habit
'Ricki'	*M. stellata* 'Rosea' with *M. liliiflora* 'Nigra' (*M.* x*soulangeana* 'Nigra')	Blooms late April, flowers 15 cm wide, flowers red/purple, upright habit
'Susan'	*M. stellata* 'Rosea' with *M. liliiflora* 'Nigra' (*M.* x*soulangeana* 'Nigra')	Blooms late April, flowers are fragrant and red/purple, compact habit
'Jane'	*M. liliiflora* 'Reflorescens' with *M. stellate* 'Waterlily'	Blooms early May, flowers 10 cm wide, fragrant flowers, white on inside and red/purple outside, upright habit
'Pinkie'	*M. liliiflora* 'Reflorescens' with *M. stellata* 'Rosea'	Blooms late April to mid-May, flowers 18 cm wide, flowers white inside and pale red/purple outside, compact and round habit

Table 2: The "Little Girls" magnolia series (adapted from Gardiner 2000).

IV. PROPOSED CROP TRANSFORMATION

A. Crop Production Change(s) for the Future.

As outlined in the current production statistics, the primary market of *M.* x*soulangeana* today is as a deciduous flowering tree for use in the landscape. The future of this ornamental tree lies in expanding its current market beyond its use as a deciduous flowering tree into the market of woody decorative cuttings for floral design through sustainable greenhouse container production.

There are many advantages to producing containerized *M.* x*soulangeana* in a greenhouse One advantage container production has over field production is that the digging cost is completely eliminated with container production; a second advantage is that potted magnolias are more easily moved (Nelson 2003). With this advantage in mind, plant spacing can be adjusted specifically to each individual magnolia as the magnolia grows and changes (Nelson 2003). Fertilizers can also be more directly applied to the tree's root ball than can be done for those grown in field production (Nelson 2003). This could lead to savings in fertilizer applications and make the production system more sustainable. The greenhouse aspect is also an advantage in that it protects magnolias during the winter from the cold, ensuring that root-killing temperatures are not reached. The greenhouse would similarly be able to protect the magnolias' blooms from unexpected late frosts.

While there are many advantages to this new proposed system, there are also disadvantages that would have to be overcome through breeding and the strategic use of current *M.* x*soulangeana* cultivars. The first challenge to overcome would be root circling and girdling that occurs from the restriction of the tree's root system in a container (Flemer 1980). These issues are especially relevant for *M*. x*soulangeana* because of their fleshy rope-like roots that stay within 0.3 meters of a soil's surface (USDA 2006). Root circling is detrimental because it reduces the vigor and growth of the magnolia, and root girdling would lead to the eventual death of the tree (Nelson 2003). In order to keep this from occurring, the first thing a grower would need to consider is the cultivar of *M.* x*soulangeana* they plan to produce. In general, the larger a magnolia trees have larger root systems, so a smaller cultivar would need to be selected or bred. Using appropriately sized containers based on the expected plant size can also help deter the formation of circling and girdling root systems. Another solution could be the use of specific containers that discourage root circling. These methods include the use of air-pruning containers, fabric containers, or copper-coated containers (Nelson 2003). Air pruning containers and fabric containers both rely on air pruning to keep the roots from circling (Nelson 2003). Copper-coating

containers use copper hydroxide on the insides of the container to inhibit roots that come into contact with the container's side; they also encourage root branching in the system (Nelson 2003). Since the effectiveness of such techniques have yet to be evaluated for *M.* x*soulangeana,* a producer would need experiment to determine the best practice to utilize.

The second challenge that would need to be overcome would be the size of *M.* x*soulangeana.* The average height and width of this species is 6 meters to 7.6 meters and 6 meters to 9 meters respectively (Gilman & Watson 2014). For the production system being considered, this is much too large to be practical. To overcome this issue, cultivar selection would need to be implemented and the consideration of breeding and selecting new cultivars with a more manageable size would need to be deliberated. When selecting cultivars or breeding new ones, the growth rate to the *M.* x*soulangeana* would also need to be kept in mind. For example, Kiki's broom, mentioned above, is one of the smaller cultivars of *M.* x*soulangeana* that could be considered for this type of production; its average height and width is 0.61 m and 1.5 m, respectively (Buchholz & Buchholz Nursery 2015). The growth rate of this cultivar, however, is slow, so it might not be the best cultivar to be used for woody cuttings (Buchholz & Buchholz Nursery 2015).

As mentioned above, towards the end of the current production practices, *M.* x*soulangeana* is not completely drought-tolerant, and prefers well-drained, moist soils (Gilman & Watson 1994). To the best of my knowledge, no published information exists that documents any *M.* x*soulangeana* being highly tolerant to drought. However, there are existing cultivars that have moderate tolerance to droughty conditions (Kuhns & Rupp 2000, Gilman & Watson 1994). Magnolia x*soulangeana* 'Alexandria,' 'Verbanica,' 'Alba,' 'Burgundy,' and 'Lilliputian' are all cultivars of *M.* x*soulangeana* that are moderately tolerant to drought stress (Gilman & Watson 1994). In order to be sustainable, the more drought tolerant the cultivar is, the better.

B. A New Production Schedule for *Magnolia* x*soulangeana*

Since *M.* x*soulangeana* will not be sold to the consumer as a small deciduous tree and will instead be sold as woody cut flowers, a new production schedule will need to be considered. When considering production practices, the best choice would probably be propagation through stem cuttings. This is because propagating *M.* x*soulangeana* with seeds may require an addition 10 to 20 years before it initially flowers and has a harvestable product, while with stem cuttings, it would only take an additional 1 to 2 years before the tree would flower and have a harvestable product (Hartmann 2011, Treseder 1978). Another reason to use stem cuttings over seed would be that the final plant that would develop from the cuttings would be an exact copy of the parent plant, whereas the final plant grown from the seed would be variable (Gardiner 2000; Treseder 1978). The entire process for the propagation of stem cuttings would be the same, as described above, until the following late winter or spring between February and May, after transferring the cuttings to a cold frame. Instead of transplanting the rooted cuttings into the field, they can be transplanted into their final container and maintained in the greenhouse. The size of the container would depend on the final mature height of the *M.* x*soulangena* cultivar grown; a general rule of thumb is to have 2.78 L / 0.3 m of plant height (Reeves & Glasender, 2015). So if the chosen cultivar had a mature height of 1 meter, the proper container size would be between 3 gallons and 6 gallons. Following transplantation, the magnolia would need to be maintained in the greenhouse for 1 to 2 years before an actual product could be taken. This give the plant time to put on additional growth and become mature enough to flower.

At the end of 1 to 2 years, the magnolia would finally be able to be harvested for woody cuttings. Before taking any cuttings, the grower would want to determine to whom s/he is selling to and what time would be best to take cuttings. Generally, the sales of cut woody flowers is best before the landscape plant naturally blooms and decreases during the natural bloom time (Greer & Dole 2009). A grower could also potentially hold cuttings in a cooler until the landscape plants blooming period is over, but it is likely that not as much money would be made when

compared to earlier sales (Greer & Dole 2009). However, it is harder to force cut branches the further away the time is from the natural blooming period (Greer & Dole 2009).

This problem can nevertheless be overcome in this new production system by increasing the temperature in the greenhouse so that it resembles spring. This would allow cuttings to be taken sooner and with less difficulty in forcing than ones grown in the landscape. In the Midwest, U.S., the natural blooming time for *M.* x*soulangeana* is sometime between April and May (Gardiner 2000; Raver 1993). If temperatures were to begin to resemble spring in late January, cuttings could potentially be taken in February, which is around the natural blooming time for *M.* x*soulangeana* grown in California (Gardiner 2000). Following harvest, the cuttings should be placed in water (Greer & Dole 2009). Additionally, if the new cultivar was a re-blooming type, a second harvest could be potentially taken in the summer.

Forcing cuttings can take up to eight weeks depending on how close the cuttings were taken to their natural blooming time (Grupp n.d.). To force cuttings, the stems should be left in water and the containers encompassing the stems should be placed in a room with temperatures between 15.5 °C and 21°C (Grupp n.d.). The water sustaining the cuttings should be swapped with new water periodically; floral preservatives can also be added in order to help control bacteria (Grupp n.d.). If the cuttings are not going to be forced, the best time to harvest them would be just as the sepals are beginning to open (Greer & Dole 2009). Like with forcing, once the stems are harvested, they should be placed in water (Greer & Dole 2009). The best way to ship magnolia woody cuttings is in water at temperatures between 2 °C and 5 °C. These cuttings will survive under these conditions for about a week (Greer & Dole 2009).

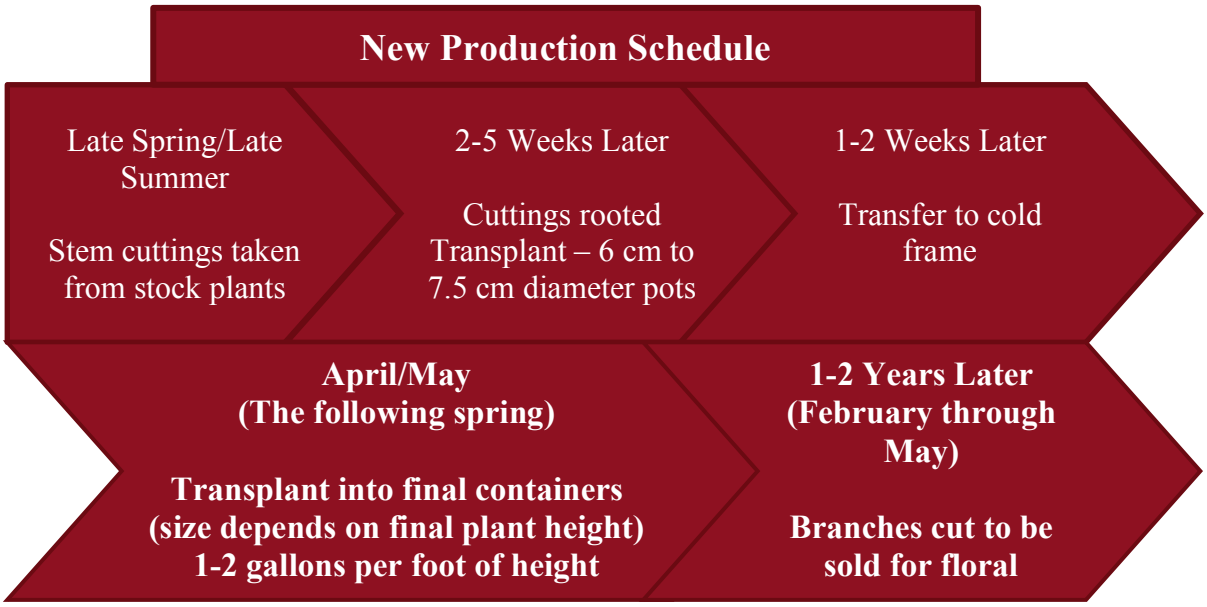

Figure 8: New production schedule for *M.* x*soulangeana* for use as woody cut flowers in a container production system (adapted from Reeves & Glasender 2015, Hartmann 2011, Treseder 1978).

C. *Magnolia* x*soulangeana* Ideotype

After breeding and selection has been done, the ideotype for *Magnolia* x*soulangeana* in container production for use as woody cut flowering stems would be a small cultivar with a moderate to moderately high growth rate and resistance to drought. A small cultivar would be ideal because smaller containers could be used to maintain each plant and more plants could be maintained in greenhouse production. This trait may be somewhat difficult to breed for however, since most of the current cultivars range in heights of 6 meters and 7.6 meters (Gilman & Watson 2014). However, this trait is possible to achieve and can be seen in the cultivar 'Kiki's Broom'. The small cultivar would also ideally have a smaller root system and/or have a root system that could be managed with the use of air-pruning containers, fabric containers, or copper coated containers, as discussed above. Research would need to be conducted to determine the best way to prevent root circling and girdling.

The growth rate for this cultivar would need to be moderate to moderately high in order for the plant to recover from each harvest quickly. If a grower was to only harvest in the early spring, then a moderate growth rate would not be limiting to production. However, if a grower had re-blooming types and wanted to harvest twice, once in early spring and once in the summer, a higher growth rate would be more suitable. Additionally, breeding could be done to select re-blooming types with flowers comparable to those that appear in the spring, since summer flowers are often slightly malformed and smaller than the spring flowers (Galitzki 2001).

Drought tolerance is another important trait to possess because it would make the production of *M.* x*soulangeana* more sustainable. It may also potentially decrease risk in the sense that it would be harder to cause the plant stress due to lack of water. Like with cultivar size, this trait may be hard to select for due to the fact that most cultivars have at most a moderate tolerance to drought (Kuhns & Rupp 2000, Gilman & Watson 1994). Furthermore, wild magnolias are most commonly found growing along the margins of ponds and streams (Gardiner 2000). This suggests there may not be much breeding material available with a high tolerance to drought.

Two final traits to select for when considering the final product – woody stem cut flowers – would be a longer vase life and color variety. Cut stems from *M.* x*soulangeana* have a relatively short vase life because they are easily bruise, are prone to wilting, and shed their petals (Greer & Dole 2009). Expansion of vase life would increase the desirability of the product. Color variety is also important when considering the consumer. Most cultivars of *M.* x*soulangeana* range in color from white to pink to purple. Maintaining these colors would increase the marketability of the cut flowers for consumers interested in purchasing a particular color.

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